

Petroleum Systems Risk in the Deep Gas Plays of the Middle East: A Regional Screening Approach

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Abstract

The Middle East hosts the majority of the world's hydrocarbons and has significant yet-to-find values. Most discoveries have been within simple structural trap geometries, with much of the production from giant/super- giant fields. As we move through the early stages of the energy-transition, gas becomes a key resource and to locate these additional accumulations, exploration will focus on drilling deeper and older targets below the oil- rich Cretaceous-Jurassic intervals. However, assessing this deep stratigraphy can be challenging due to regional variations in the extent of penetrations into strata older than the Triassic. To assess the qualities of these deep petroleum systems, a regional screening approach is applied.

The Silurian organic-rich shales of the Qusaiba Formation and equivalents are the main source rocks for the pre- Jurassic plays. The regional distribution of the Qusaiba Formation relates in part to its preservation beneath the Late Palaeozoic "Hercynian" unconformity, the occurrence of major structural depressions and paleobathymetric variations related to the Late Ordovician glaciation. At present-day depths, the Silurian source rock is extensively overmature. Therefore, understanding the timing of charge, the nature of migration pathways and the timing and presence of structural development is required.

Reservoir horizons charged by the Silurian include the shallow-marine siliciclastics of the Ordovician Qasim Formation and Devonian Jauf Formation, highly heterogeneous glacial-terrestrial siliciclastics of the Hirnantian Sarah Formation and Carboniferous-Permian Unayzah Formation and the carbonates of the Permo-Triassic Khuff Formation and Middle Triassic Jilh Formation and equivalents. Reservoir risk associated with the Unayzah Formation and Pre-Qusaiba clastics include reservoir quality associated with depth of burial, silica cementation and preservation beneath the "Hercynian" unconformity. Risks associated with the carbonates of the Khuff and Jilh formations is the ability to predict the location of favourable grainstone facies and the presence of dolomitization. This can be regionally constrained using known hydrocarbon accumulations, sequence stratigraphy, tectonic lineaments, and bed shear stress model predictions derived from palaeoclimate and modelling of tidal and wave energy regimes.

Across the region, variations and risks associated with seal quality are also evident. For example, in the Sudair Formation (a seal to the Khuff Formation) the principal shale seals becomes thinner and more carbonate dominated eastward posing a significant risk on seal development. Whilst assessing the distribution of petroleum system elements is critical, it is also important to understand other petroleum system processes as risks. For example, in the Khuff and Jilh formations, gas souring from thermochemical sulphate reduction is significant. This reaction is associated with the migration of gas through carbonate and evaporite successions at temperatures >140oC to produce hydrogen sulfide and diminish gas quality.

Understanding deep gas systems within the Middle East requires a regional approach to fully appreciate and contextualise the distribution of petroleum system elements and processes. We can use a play screening workflow to not only assess the likely presence and effectiveness of each petroleum system element but understand what the key risks for each area will be and how this will influence petroleum system development.